



Inventory of mammals in protected reserves and natural habitats of Tripura, northeast India with notes on existing threats and new records of Large Footed Mouse-eared Bat and Greater False Vampire Bat

Joydeb Majumder¹, Koushik Majumdar², Partha Pratim Bhattacharjee¹ and Basant Kumar Agarwala^{1*}

1 Tripura University, Department of Zoology, Ecology and Biodiversity Laboratories, Suryamaninagar 799022, Tripura, India

2 Tripura University, Department of Botany, Plant Taxonomy and Biodiversity Laboratory, Suryamaninagar 799022, Tripura, India

* Corresponding author. E-mail: bagarwala00@gmail.com

Abstract: Twenty-four species representing 21 genera, 16 families and 7 orders of mammals were recorded in the Tripura state, northeast India, from an inventory done from 2006 to 2012. Ten of these species were found in wildlife sanctuaries as well as in primary forests. Four species were recorded exclusively from the wildlife sanctuaries and ten species were recorded only from primary forests. Order Primates was the most diverse group represented by 6 species from 4 genera in 3 families. Frequency sightings data showed that 11 species were rare, 2 species were occasional, one species was frequent, and another 10 species were common. Two species, Large-footed Mouse-eared Bat, *Myotis* sp., and Greater False Vampire Bat, *Megaderma lyra*, are new records from the study area. Overall, 23 of the 24 species recorded are listed in the IUCN Red List, 14 species are listed in CITES, and 14 species are protected under the Indian Wildlife Protection Act, 1972. Threats being faced by many of the recorded mammals from human encroachments are highlighted.

Key words: inventory, mammals, northeast India, primary forests, wildlife reserves

INTRODUCTION

There is a lack of information regarding the distribution and life history attributes even for relatively well-known groups such as mammals (Medellín and Soberon 1999) of tropical forests, which are more species-rich than most other ecosystems (Gentry 1986; Wilson 1988). Mammals play important roles in the distribution and range extension of tropical plants by various activities like dispersal of seeds and fruits, pollination, browsing by herbivores, and by trampling and defecation; all these

contribute to the distribution and recycling of nutrients, and succession of plant communities in forests (Dirzo et al. 2009; Jones and Safi 2011). Due to the lack of an inventory of mammalian species richness in some of the difficult and remote areas of tropical forests in northeast India and increasing human encroachments, application of effective and sustainable conservation strategies of natural resources in biodiversity-rich areas remain elusive (Soule and Kohm 1989).

The northeast region of India is the transition zone of India with the Indo-Myanmar, Indo-Malayan and Indo-Chinese biogeographical regions, and contains two global biodiversity hotspots represented by the 'eastern Himalaya' and the 'Indo-Myanmar region' (Myers et al. 2000). A diverse set of habitats coupled with long-term geological stability has resulted in high levels of endemism of animals and plants in this part of South-east Asia. However, its biodiversity is under imminent threat due to deforestation of primary forests, habitat modification due to developmental activities, and shifting cultivation by ethnic peoples. The condition has been aggravated in the last two decades in the state of Tripura due to the increased use of forested lands for rubber plantations (*Hevea brasiliensis* Müll. Arg.) (4.89% of state area of 10,492 km²) (Ray et al. 2014), thereby causing fragmentation of natural habitats (Agarwala and Bhattacharjee 2012; Majumder et al. 2014).

India is home to at least 428 species and 338 subspecies of mammals from 48 families and 14 orders (Sharma et al. 2014). The northeastern region (22–30° N and 89–97° E) accounts for 243 species and 158 subspecies from 35 families and 13 orders, and these include 54% of the threatened mammals found in the country (Choudhury 2006). These included record of a new primate species, *Macaca munzala* Sinha, Datta, Madhusudan and Mishra,

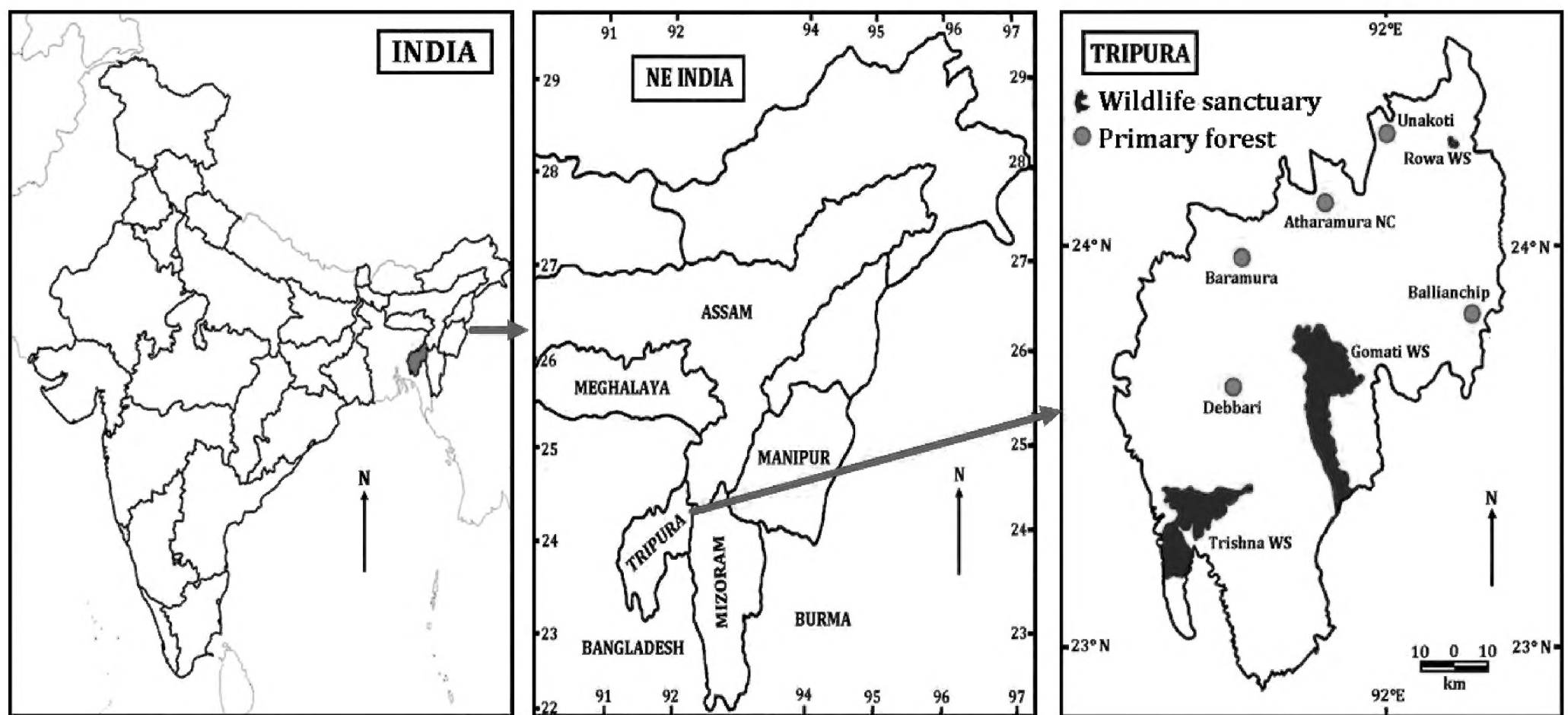


Figure 1. Maps of India and northeast India showing eight study sites in Tripura.

2005 (Arunachal macaque), from high elevations of Arunachal Pradesh (Sinha et al. 2005). At the time of this study, the mammalian fauna of Tripura was represented by 90 species from 65 genera and 10 orders (Gupta and Mukherjee 1994). However, Bhattacharyya and Ghosh (2002) reported only 44 species and subspecies from 33 genera and 9 orders from the state. Evidently, there was something amiss between the two reports in terms of difference in number of mammal species reported. In fact, perusal of these literature showed that both the reports heavily relied on past data or quoted from other sources without reference to voucher specimens (Blyth 1844; Sclater 1891; Khajuria 1955; Agarwal and Bhattacharyya 1977; Mukherjee et al. 1993; Gupta 1994; Das et al. 1995), and directly observed only 18 species namely, *Arctitis binturong* (Raffles, 1822), *Artherurus assamensis* Thomas, 1921, *Bos gaurus* Smith, 1827, *Cervus unicolor* Kerr, 1792, *Cuon alpinus* (Pallas, 1811), *Elephas maximus* Linnaeus, 1758, *Felis chaus* Schreber, 1777, *Melursus ursinus* (Shaw, 1791), *Muntiacus muntjak* (Zimmerman, 1780), *Neofelis nebulosa* (Griffith, 1821), *Panthera pardus* (Linnaeus, 1758), *Sus scrofa* Linnaeus, 1758, *Macaca nemestrina* (Linnaeus, 1766), *M. mulatta* (Zimmerman, 1780), *Hoolock hoolock* (Harlan, 1834) and *Trachypithecus phayrei* (Blyth, 1847) (Mukherjee et al. 1993; Gupta 2000). More recently, *Axis axis* (Erxleben, 1777), *Herpestes urva* (Hodgson, 1836), *Hystrix indica* (Kerr, 1792), and *Viverricula indica* (Saint-Hilaire, 1803) were also reported from Sepahijala wildlife sanctuary based on direct observations (Kumar et al. 2013). However, none of the recorded species, stated above, carried any reference on the status of their vouchers and majority of the 90 species reported by Gupta and Mukherjee (1994) or 44 species reported by Bhattacharyya and Ghosh (2002) remained un-validated for their dates, and locations of actual occurrence from the Tripura state.

In the present communication, the results of an inventory of naturally occurring terrestrial mammals that were observed or sighted by the authors from three wildlife sanctuaries and five widely separated primary forests in the Tripura state during six years from 2006 to 2012 are reported. Imminent threats faced by these animals that were actually sighted by the authors in and around the primary forests are also highlighted.

MATERIALS AND METHODS

Study Site

Tripura (22°56' N–24°32' N and 91°10' E–92°21' E; elevation: 12–940 m) comprises an area of 10,492 km². Topographically, it is a state of hills, plains, valleys and river basins, and forms an integral part of the Indo-Myanmar global biodiversity hotspot (Myers 2000). The state shares an 837 km long international boundary with Bangladesh and a common inter-state boundary with Mizoram (109 km) and Assam (53 km) of northeast India (Figure 1). The forest cover of the state is about 60% (Anonymous 2006). The vegetation of the primary forests, representing climax communities, is comprised of semi-evergreen, moist deciduous, moist mixed deciduous forests and secondary bamboo brakes that include 1583 species of vascular plants (Deb 1981–1983; Majumdar et al. 2012). The state falls in the humid tropical zone, with a minimum temperature of 10.4° C in winter and maximum of 36.8° C in summer, and an average humidity recorded in the range of 70–80% throughout the year. Due to the south-west monsoon, Tripura receives an average annual rainfall of 2,000–3,000 mm.

Data collection

Inventory was done from November 2006 to May 2012. Each of the three wildlife sanctuaries, viz.,

Trishna Wildlife Sanctuary (Trishna WS), Rowa Wildlife Sanctuary (Rowa WS) and Gomati Wildlife Sanctuary (Gomati WS), which are protected by law, and other five primary forest sites at Ballianchip (BC), Debbari (DB), Atharamura North Circle (Atharamura NC), Baramura (BM), and Unakoti (UK) (Figure 1), were visited twice in the dry (December/January) and wet (May/June) seasons during the six years of study under permissions granted by the Ministry of Environment and Forests, Government of India (F. No. 14/14/2005-ERS/RE dated 24.08.2006) and Tripura Biodiversity Board, Government of Tripura (F. 22/3(6)/For-JBIC/I&P/B-D/07/2336 and 4972-76 dated 07.01.2009 and 29.06.2009, respectively). Inventories were carried out between 7:00–11:00 h and between 15:00–18:00 h on two days at each study site per season, and were based on sighting of mammals and in some cases also by signs of their footprints or dry or fresh feces to help in recording the frequency occurrence of each species. Special sampling efforts were made for the search of shy animals like large footed mouse-eared bats, slow loris and greater false vampire bats in their potential habitats and for carnivores. Forest guards and local people who resided in the respective study sites helped in locating the potential sights of

these mammals. Binoculars (Vista Le 8 ´ 40 porro prism compact binocular) were used for closer observation of mammals sighted at height or at a distance, especially carnivores. Animals that were actually seen in the study sites were photographed using Cannon SLR 50D and Sony HX 100V cameras to validate the records. Two species, *F. chaus*, and *V. indica*, were found killed in separate traps set by the local people for use of these animals as food. These were also recorded in this study. Information on area (km²), their geo-coordinates, elevations, major forest types, methods used, sampling efforts made, and anthropogenic disturbances noticed at each study site are provided in Table 1. Mammals observed in the study were identified using well-known literature (Pocock 1939–1941; Prater 1971; Tikader 1983; Wang et al. 1991; Martin et al. 2001; Menon 2003; Simmons 2005; Choudhury 2006; Srinivasulu et al. 2010; Majumder and Agarwala 2015). All the photos of this study are given institutional catalogue numbers. These photos have been uploaded to the Figshare repository (<http://www.figshare.com>) for public view under the title ‘Records of Mammals from Tripura, Northeast India’. No specimen of any of the species sighted and reported in this study was collected by the authors as per the terms of

Table 1. Records of Geo-coordinates, elevation, area, major forest type, methods used, sampling efforts and anthropogenic disturbances of the study sites.

Study sites and area (km ²)	Geo-coordinates and elevation (m)	Method used	Sampling efforts	Major forest type	Anthropogenic disturbance
Trishna WS; 194.71	23°26.137' N, 091°28.184' E; 56	Forest trekking, direct observations, and interaction with forest guards on duty	Two days of December/January and two days of May/June from 2006 to 2012 by 3 persons	Tropical semi-evergreen forests, east Himalayan <i>Shorea</i> -dominant moist mixed deciduous forest and savannah woodland	Logging, hunting of wild boars, bamboo extraction, rubber plantation
Gomati WS; 389.54	23°25.462' N, 091°49.655' E; 77	Forest trekking, direct observations, and interaction with forest guards on duty	Two days of December/January and two days of May/June from 2006 to 2012 by 3 persons	Primarily mixed moist forests; patches of afforested teak plants and bamboo brakes	Logging, hunting of wild deer and porcupines for food, bamboo extraction, shifting cultivation by ethnic people
Rowa WS; 0.85	24°17.480' N, 092°09.903' E; 78	Forest trekking, direct observations, and interaction with forest guards on duty	One day of December/January and one day of May/June from 2006 to 2012 by 2 persons	Dominated by secondary moist deciduous forest and patches of bamboos of different kinds	Collection of fuel woods, tourist pressure
UK; 5	24°29.901' N, 092°21.687' E; 87	Forest trekking, direct observations, and interaction with ethnic people of the locality	One day of December/January and one day of May/June from 2006 to 2012 by 2 persons	Secondary mixed moist deciduous forest and semi-evergreen forest and patches of bamboo brakes	Tourist pressure, logging
DB; 8	23°31.576' N, 091°33.523' E; 97	Forest trekking, direct observations, and interaction with ethnic people of the locality	Two days of December/January and two days of May/June from 2006 to 2012 by 3 persons	Primary semi-evergreen riparian woody vegetation and deciduous forests and bamboo brakes	Rubber plantation, bamboo extraction, logging, hunting of wild boar, deer and squirrels for food
BM; 12	23°49.540' N, 091°16.350' E; 108	Forest trekking, direct observations, and interaction with ethnic people of the locality	Two days of December/January and two days of May/June from 2006 to 2012 by 3 persons	Secondary mixed moist deciduous forests	Bamboo extraction, rubber plantation, shifting cultivation, hunting of wild boar, deer and squirrels for food
Atharamura NC; 10	24°07.691' N, 091°46.643' E; 183	Forest trekking, direct observations, and interaction with ethnic people of the locality	Two days of December/January and two days of May/June from 2006 to 2012 by 3 persons	Secondary mixed moist deciduous forest dominated by <i>Shorea</i> , <i>Ficus</i> and <i>Tecktona</i> plants; several bamboo species also present;	Shifting cultivation, logging, hunting, bamboo extraction
BC; 8	23°59.079' N, 092°16.649' E; 565	Forest trekking, direct observations, and interaction with ethnic people of the locality	Two days of December/January and two days of May/June from 2006 to 2012 by 2 persons	Semi-evergreen moist deciduous and lush evergreen moist forests dominated by several species of woody plants	Shifting cultivation, human habitations and related developmental activities leading to fragmentation of forest, logging, hunting of rhesus macaques, bamboo extraction

permissions of the funding agencies. Specimens of the two species, *F. chaus*, and *V. indica*, found trap-killed in the study, were taken away by local people who had set the traps. Their photos are also included in the Figshare repository.

Species reported in this study are categorized into four arbitrary categories based on sighting of mammals and also by footprints or dry or fresh feces in cases of *Elephas maximus indicus*, *Sus scrofa*, *Nycticebus bengalensis*, *Trachypithecus pileatus*, *T. phayrei*, *Macaca mulatta* as signs of their presence in recent past to help in recording their frequency occurrence in the study sites. The categories are: 1, rare (1–5 records); 2, occasional (6–10 records); 3, frequent (11–15 records); or 4, common (>15 records) (Table 2).

RESULTS

Mammalian species and their distribution

Mammalian species recorded from the eight study sites are presented in Table 3 and Figure 2. These included 24 species from 21 genera, 16 families and 7 orders.

Ten of these species were found in protected wildlife sanctuaries as well as in primary forests. Four species were recorded from the wildlife sanctuaries alone and ten other species from primary forests only. Large footed mouse-eared bat (*Myotis* sp.) (Figure 2l) and Greater false vampire bat (*Megaderma lyra* Geoffroy, 1810) are new records from the study area (Figure 2i). The genus *Myotis* is species rich and has wide distribution in the Old and New Worlds (Simmons 2005). Small body size (52.46mm long and 26.52mm wide, *n* = 3) bats of *Myotis* sp., a genus characterized by mouse-like face with muzzle long and face hairy, ears longer than broad, long and tapering tragus- a cutaneous extension of the external opening of ear, and nostril apertures small and closely placed in comparison to other known genera of the family Vespertilionidae (Pocock 1939–41; Srinivasulu et al. 2010), were sighted in groups of 3–4 individuals living in rock crevices of soft rocks of the hills of the southern part of Tripura in relatively cool, highly moist and undisturbed locations. The lone specimen of the Greater false vampire bat, *M. lyra*, was sighted in a discarded

Table 2. List of species of mammals observed in wildlife sanctuaries and primary forests of Tripura with their figure no., photo catalogue no., conservation status, frequency of occurrence and methods of observations used. Photos of the listed species can be found in the website on ‘Figshare’.

Species	Figure	Photo catalogue no.	Conservation status			Frequency of occurrence	Method of observations
			IUCN	CITES	IWPA		
<i>Bos gaurus</i>	2 (a)	TU/Mam/Arti/Bovi/001	VU	APP-I	SCH-I	O	Direct sighting, footprints
<i>Axis axis</i>	2 (b)	TU/Mam/Arti/Cervi/002	LC	*	SCH-III	R	Direct sighting
<i>Muntiacus muntjak</i>	2 (c)	TU/Mam/Arti/Cervi/003	LC	*	SCH-III	R	Direct sighting, observation of carcass and meat of a killed specimen
<i>Sus scrofa</i>	2 (d)	TU/Mam/Arti/Sui/004	LC	*	SCH-III	C	Direct sighting, observation of footprints, dry and fresh feces
<i>Felis chaus</i>	2 (e)	TU/Mam/Car/Feli/005	LC	APP-II	*	C	Direct sighting, observation of meat and dead specimen found in a trap set by local people
<i>Herpestes javanicus</i>	2 (f)	TU/Mam/Car/Herp/006	LC	APP-III	*	C	Direct sighting, observation of a road-killed specimen
<i>Herpestes urva</i>	2 (g)	TU/Mam/Car/Herp/007	LC	APP-III	*	R	Direct sighting
<i>Viverricula indica</i>	2 (h)	TU/Mam/Car/Viver/008	LC	APP-III	SCH-II	R	Dead specimen sighted in a trap set by local people
<i>Megaderma lyra</i> ⁺	2 (i)	TU/Mam/Chi/Mega/009	LC	*	*	R	Direct sighting
<i>Cynopterus sphinx</i>	2 (j)	TU/Mam/Chi/Ptero/010	LC	*	*	C	Direct sighting
<i>Pteropus giganteus</i>	2 (k)	TU/Mam/Chi/Ptero/011	LC	APP-II	*	C	Direct sighting
<i>Myotis</i> sp ⁺	2 (l)	TU/Mam/Chi/Vesp/012	*	*	*	R	Direct sighting
<i>Macaca mulatta</i>	2 (m)	TU/Mam/Prim/Cerco/013	LC	APP-II	SCH-II	C	Direct sighting
<i>Macaca nemestrina</i>	2 (n)	TU/Mam/Prim/Cerco/014	VU	*	SCH-II	C	Direct sighting
<i>Trachypithecus phayrei</i>	2 (o)	TU/Mam/Prim/Cerco/015	EN	APP-II	SCH-I	C	Direct sighting, observation of footprints, dry and fresh feces
<i>Trachypithecus pileatus</i>	2 (p)	TU/Mam/Prim/Cerco/016	VU	APP-I	SCH-I	C	Direct sighting
<i>Hoolock hoolock</i>	2 (q)	TU/Mam/Prim/Hylo/017	EN	APP-I	SCH-I	O	Direct sighting
<i>Nycticebus bengalensis</i>	2 (r)	TU/Mam/Prim/Lori/018	VU	APP-I	SCH-I	R	Direct sighting
<i>Elephas maximus indicus</i>	2 (s)	TU/Mam/Probo/Elep/019	EN	APP-I	SCH-I	F	Direct sighting, observation of footprints, dry and fresh feces
<i>Hystrix indica</i>	2 (t)	TU/Mam/Rod/Hyst/020	LC	*	SCH-III	R	Direct sighting
<i>Dremomys lokriah</i>	2 (u)	TU/Mam/Rod/Sciu/021	LC	*	*	R	Direct sighting
<i>Callosciurus pygerythrus</i>	2 (v)	TU/Mam/Rod/Sciu/022	LC	*	*	C	Direct sighting
<i>Ratufa bicolor</i>	2 (w)	TU/Mam/Rod/Sciu/023	NT	APP-II	SCH-II	R	Direct sighting
<i>Tupaia belangeri</i>	2 (x)	TU/Mam/Scan/Tupai/024	LC	APP-II	*	R	Direct sighting

⁺ denotes first record from Tripura; * indicates not listed in IUCN, CITES or IWPA.

dwelling hut on the edge of Atharamura NC.

The order Primates was the most diverse group, represented by 6 species from 4 genera and 3 families; The orders Artiodactyla and Chiroptera were each represented by 4 species from 4 genera in 3 families, and the order Carnivora was represented by 4 species from 3 genera in

3 families. The orders Proboscidea and Scandentia were represented by one species each only. On the basis of frequency of records, 11 species are considered as rare, 2 species as occasional, and one species as frequent. The remaining 10 species are considered common (Table 3).

In addition to the species whose presence in the

Table 3. Species of mammals recorded in the wildlife sanctuaries and primary forests of this study and are denoted by the symbols ‘√’ for presence or ‘x’ for absence in respective study sites. Photos of the listed species can be found in the website on ‘Figshare’.

Species	Literature used for identification	Wildlife Sanctuaries			Primary Forests					
		Trishna WS	Gomati WS	Rowa WS	UK	DB	BM	Atharamura NC	BC	
Artiodactyla: Bovidae										
<i>Bos gaurus</i> Smith, 1827	Menon, 2003	√	×	×	×	×	×	×	×	×
Artiodactyla: Cervidae										
<i>Axis axis</i> (Erxleben, 1777)	Pocock, 1939-41; Menon, 2003	√	×	√	×	×	√	√	√	√
<i>Muntiacus muntjak</i> (Zimmermann, 1780)	Pocock, 1939-41; Menon, 2003	√	×	×	×	×	×	√	√	×
Artiodactyla: Suidae										
<i>Sus scrofa</i> L., 1758	Martin et al. 2001; Menon, 2003	√	√	√	√	√	√	√	√	√
Carnivora: Felidae										
<i>Felis chaus</i> Schreber, 1777	Pocock, 1939-41; Choudhury, 2006	√	√	√	√	×	×	√	√	×
Carnivora: Herpestidae										
<i>Herpestes javanicus</i> (Saint-Hilaire, 1818)	Pocock, 1939-41; Menon, 2003	√	√	×	√	×	×	√	√	×
<i>Herpestes urva</i> (Hodgson, 1836)	Pocock, 1939-41; Menon, 2003	√	√	×	×	√	√	√	√	×
Carnivora: Viverridae										
<i>Viverricula indica</i> (Saint-Hilaire, 1803)	Pocock, 1939-41; Choudhury, 2006	√	×	×	×	×	×	×	×	×
Chiroptera: Megadermatidae										
<i>Megaderma lyra</i> Geoffroy, 1810	Menon, 2003; Simmons, 2005	×	×	×	×	×	×	√	√	×
Chiroptera: Pteropodidae										
<i>Cynopterus sphinx</i> (Vahl, 1797)	Menon, 2003; Simmons, 2005	×	√	×	√	×	×	×	×	√
<i>Pteropus giganteus</i> (Brünnich, 1782)	Menon, 2003; Simmons, 2005	×	×	×	√	×	√	√	√	×
Chiroptera: Vespertilionidae										
<i>Myotis</i> sp. ⁺	Molur and Srinivasulu, 2008	×	×	×	×	√	×	×	×	×
Primates: Cercopithecidae										
<i>Macaca mulatta</i> (Zimmermann, 1780)	Pocock, 1939; Prater, 1971; Menon, 2003	√	√	√	√	√	√	√	√	×
<i>Macaca nemestrina</i> (L., 1766)	Pocock, 1939-41; Prater, 1971; Menon, 2003	×	√	×	×	×	×	×	×	×
<i>Trachypithecus phayrei</i> (Blyth, 1847)	Pocock, 1939-41; Prater, 1971; Menon, 2003	×	×	×	√	√	×	√	√	×
<i>Trachypithecus pileatus</i> (Blyth, 1943)	Pocock, 1939-41; Prater, 1971; Menon, 2003	√	×	×	×	×	×	×	×	×
Primates: Hylobatidae										
<i>Hoolock hoolock</i> (Harlan, 1834)	Pocock, 1939-41; Prater, 1971; Menon, 2003	×	×	×	×	×	√	√	√	×
Primates: Lorisidae										
<i>Nycticebus bengalensis</i> (Lacepede, 1800)	Pocock, 1939-41; Prater, 1971; Menon, 2003	√	×	×	×	√	×	×	×	×
Proboscidea: Elephantidae										
<i>Elephas maximus indicus</i> Cuvier, 1798	Tikader, 1983; Menon, 2003;	×	×	×	×	√	√	√	√	×
Rodentia: Hystricidae										
<i>Hystrix indica</i> Kerr, 1792	Prater, 1971; Menon, 2003	×	×	×	×	×	√	√	√	×
Rodentia: Sciuridae										
<i>Dremomys lokriah</i> (Hodgson, 1836)	Prater, 1971; Menon, 2003	×	×	×	√	×	√	√	√	√
<i>Callosciurus pygerythrus</i> (Saint Hilaire, 1832)	Prater, 1971; Menon, 2003	√	√	√	√	√	√	√	√	√
<i>Ratufa bicolor</i> (Sparman, 1778)	Prater, 1971; Menon, 2003	×	×	×	√	×	×	√	√	√
Scandentia: Tupaiidae										
<i>Tupaia belangeri</i> (Wagner, 1841)	Wang et al.1991; Choudhury, 2006; Majumder and Agarwala, 2015	×	×	×	×	×	×	√	√	×
Total (24 species 21 genera)		12	8	5	10	8	10	17	17	6

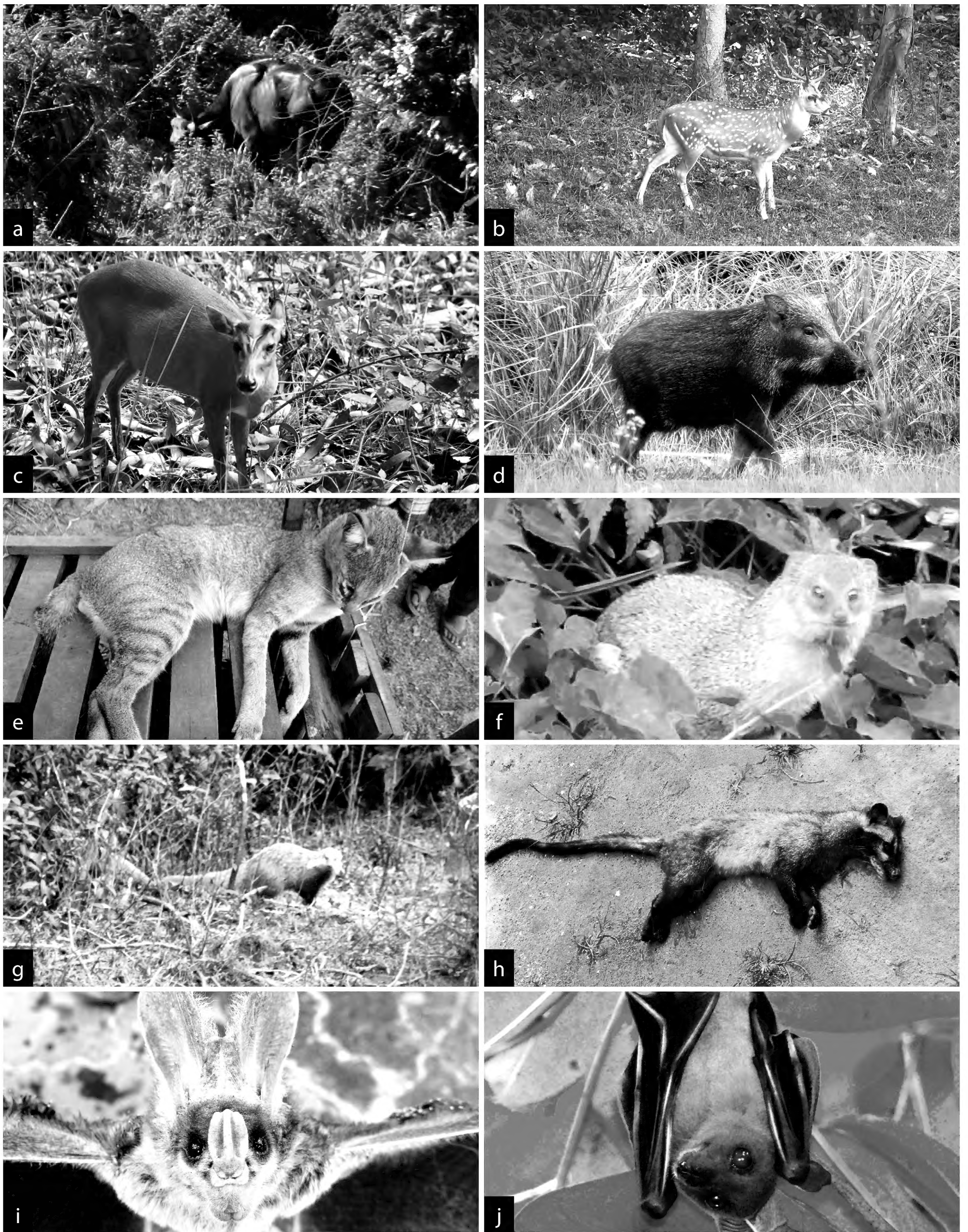


Figure 2. Mammals observed with names of locations as per abbreviations used in the text: (a) Trishna WS: *Bos gaurus* (Indian Bison), (b) Trishna WS: *Axis axis* (Spotted Deer), (c) Trishna WS: *Muntiacus muntjak* (Barking Deer), (d) BM: *Sus scrofa* (Wild Boar), (e) Rowa WS: *Felis chaus* (Jungle Cat), (f) Gomati WS: *Herpestes javanicus* (Small Asian Mongoose), (g) Trishna WS: *Herpestes urva* (Crab-eating Mongoose), (h) Trishna WS: *Viverricula indica* (Small Indian Civet), (i) Atharamura NC: *Megaderma lyra* (Great False Vampire Bat), (j) UK: *Cynopterus sphinx* (Short-nosed Indian Fruit Bat). (Continued.)



Figure 2. Continued. (k) BC: *Pteropus giganteus* (Indian Flying Fox), (l) DB: *Myotis* sp. (Large Footed Mouse-eared Bat), (m) Trishna WS & BM: *Macaca mulatta* (Rhesus Macaque), (n) Gomati WS: *Macaca nemestrina* (Pig-tailed Macaque), (o) DB: *Trachypithecus phayrei* (Phayre's Leaf Monkey), (p) Trishna WS: *Trachypithecus pileatus* (Capped Langur), (q) Atharamura NC & DB: *Hoolock hoolock* (Hoolock Gibbon), (r) Trishna WS: *Nycticebus bengalensis* (Slow Loris), (s) DB: *Elephas maximus indicus* (Asian Elephant), (t) Atharamura NC: *Hystrix indica* (Indian Porcupine). (Continued).



Figure 2. Continued. (u) UK: *Dremomys lokriah* (Orange-bellied Himalayan Squirrel), (v) UK: *Callosciurus pygerythrus* (Irrawaddy Squirrel), (w) BC: *Ratufa bicolor* (Malayan Giant Squirrel), and (x) Atharamura NC: *Tupaia belangeri* (Northern Tree Shrew).

study sites we were able to document (Table 3), we also recorded the following six species based on indirect evidences collected from forest guards of the wildlife sanctuaries and local peoples who were residents of the primary forests: *Canis aureus* Linnaeus, 1758, Golden Jackel, *Prionailurus bengalensis* (Kerr, 1792), Leopard cat (Carnivora: Felidae); *Lutrogale perspicillata* (Saint-Hilaire, 1826), Smooth-coated Otter (Carnivora: Mustelidae); *Ursus thibetanus* (Cuvier, 1823), Asian Black Bear (Carnivora: Ursidae); *Arctictis binturong* (Raffles, 1821), Binturong (Carnivora: Viverridae); and *Lepus nigricollis* Cuvier, 1823, Indian Hare (Logomorpha: Leporidae).

Species composition and distribution pattern of 24 mammal species that were sighted showed considerable variation between different study sites. The least number of species (5) occurred in Rowa WS. Species richness in the remaining seven study sites was found to vary from 6 to 17 species (Table 2). Species that were recorded exclusively from a single study site included *Bos gaurus* from Trishna WS, *Myotis* sp. from Gomati WS, and *M. lyra* and *Tupaia belangeri* from Atharamura NC. Majority of the recorded species were herbivores (79.17%), for example, *Bos gaurus*, *Axis axis*, *Elephas maximus indicus*, *Hoolock hoolock* (foliage feeders); and *Cynopterus sphinx*, *Pteropus giganteus* (fruit feeders) among others. These belonged to 19 species from 17 genera, 12 families and 6 orders. One species, *Myotis* sp., was insectivorous, and the remaining 16.66% species, viz. *Felis chaus*, *Herpestes javanicus*, *Herpestes urva*, and *Viverricula indica*, were carnivorous (4 species in 3 genera and 3 families).

Existing threats and consequences

Anthropogenic activities such as over-extraction of forest resources, illegal logging, plantation of exotic rubber, tourist pressure, conversion of forest land for habitations, road construction and farming, forest fires for shifting cultivation in hills, and hunting of animals by gun or capturing by use of traps for meat by native population have caused minor to major degradations of natural habitats of several of these mammals (Table 1; Figure 3). In this study, several canopy gaps were noticed which made the wildlife sanctuaries as well as primary forests scrappy and are considered major threats for arboreal mammals like *Nycticebus bengalensis*, *Trachypithecus pileatus*, *T. phayrei*, *Macaca mulatta*, *M. nemestrina*, *H. hoolock*, *Ratufa bicolor*, and *Dremomys lokriah*. Cultivation of rubber plants of African origin inside and on the edges of primary forests is an emerging concern for the existing fauna.

Conservation status

Globally, 23 of the 24 species recorded in this study are listed in the Red List of threatened mammalian species (IUCN 2014). Of these, 15 species (65.22%) are assessed as the Least Concern (LC), 4 species (17.39%) as Vulnerable (VU), 3 species (13.04%) as Endangered (EN), and one species (4.35%), *R. bicolor*, as Near Threatened (NT) (IUCN 2014) (Table 3). Fourteen species (58.33%) are also listed in CITES under appendices I, II and III as threatened or endangered for commercial reasons. These include 5 species listed in Appendix I, 6 species in Appendix II, and another 3 species listed in Appendix III (Table 3) (CITES 2014). Among the studied species, 14



Figure 3: Threats recorded at different study sites indicated by their respective abbreviated names: (a) BC: meat of Barking Deer, (b) Atharamura NC: dry feces of Barking Deer (c) Gomati WS: logs of forest felling, (d) Atharamura NC: a road-killed wild animal, (e) BC: smokes of forest fire for shifting cultivation in distant hills, (f) BC: a huntsman, (g) Trishna WS: a view of rubber plantation, (h) BM: stocks of bamboo shoots after extraction from forests.

are protected under the Indian Wildlife Protection Act, 1972 (Sharma et al. 2014).

DISCUSSION

This study reports 24 species from 21 genera, 16 families and 7 orders based on their direct observation in wildlife sanctuaries and primary forests of Tripura, northeast India. A comparison of faunal study of mammals of Tripura between the present study and previous studies (Mukherjee et al. 1993; Gupta and Mukherjee

1994; Gupta 2000; Bhattacharyya and Ghosh 2002) revealed that 22 of the species observed in this study were also reported earlier. New records of two species of bats, *Myotis* sp. and *M. lyra*, are significant addition to the distribution of these mammals from this part of South Asia. Following the taxonomic key and descriptions of known *Myotis* species from South and Southeast Asia (Blanford 1888–1891; Srinivasulu et al. 2010), the species of this study shows similarity with *M. hasseltii* (Temminck, 1840) (Lesser Large-footed mouse-eared

bat) in the characters of length of body and ears, origin of wings above the ankle of the foot and tragus short and narrow, but differs from *M. hasseltii* in having ears convex on outer margins in basal part which gradually tapers in to rounded tips in place of narrow ears with narrow tips. *Myotis hasseltii* has been reported from West Bengal in India, Cambodia, Indonesia, Malaysia, Myanmar, Sri Lanka, Thailand and Vietnam and its habitat range include dry forests, river basins, coastal habitat and caves (Bates et al. 2008). Before this study, Greater false vampire bat, characterized chiefly by dorsal surface of nose leaf-shaped, was known from Arunachal Pradesh, Assam, Meghalaya, and Nagaland in northeast India (Choudhury 2006; IUCN 2014). Present record extends its distribution further to southern part of northeast India by about 350 km from the nearest forests of Meghalaya with the potential of its presence further east in the forests of adjacent state of Mizoram, about 200 km from its site of location in Tripura (Figure 1).

Previous studies have shown that variation in species composition and distribution pattern of animals in an area largely depend on habitat conditions such as plant species composition and environmental gradients (Hawkins et al. 2003; Majumder et al. 2012). Human disturbances adversely affect the abundance and conservation of biodiversity of small and large mammals, both (Gupta 2000). Forest fires for shifting cultivation by native people result in rapid destruction of the natural habitats and niches. Significant decline in population size of *N. bengalensis* in Arunachal Pradesh in last two decades has been attributed to the prevalent shifting cultivation among the native peoples of that state (Kumar et al. 2014). Rubber plantations is another threat from mono-cultivation habitat in forested areas which is expanding at an alarming rate in Tripura and has already encroached the natural habitats of wild animals (Anonymous 2010–2011; Ray et al. 2014). Man-animal conflicts are often reported in local print and visual media which create negative response among the local inhabitants towards wild animals despite large-scale awareness campaign.

Thus, the results of this study show that primary forests contained more mammal species than protected sanctuaries. Some of the critically endangered species such as *B. gaurus*, and *T. phayrei* appear to be well protected in sanctuaries. However, there is an urgent need for area-specific and species-specific conservation strategies to save the last viable populations of many threatened mammals sighted in this study from human encroachments in the Tripura state which forms an integral part of Indo-Myanmar biogeographical zone.

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